

# **LIFELONG LEARNING PROGRAMME**

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## 3D Virtual Training Laboratory in Cutting Tools

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**Abstract:** This paper presents 3D virtual training laboratory in Cutting Tools. The laboratory presented will be used for virtual learning in different engineering student courses, where constructive and geometrical cutting tools characteristics are examined. A conceptual laboratory model and virtual learning methodology are given.

**Key words:** virtual learning, virtual laboratory, cutting tools, 3D learning, 3D models

### INTRODUCTION

New technologies provide many ways to enhance and extend educational activities. Recently, the use of virtual laboratories, simulating real experimental work in the learning process, is getting more and more popular. One of the reasons is the low cost of the virtual environment, compared to the real laboratory cost, which is sometimes very high. 3D virtual laboratories are designed to enrich and complete the traditional face-to-face learning with interactive, self-learning tools, including capabilities of modern CAD Systems. Students find virtual laboratories as fun and engaging, because training in virtual laboratories uses not just pictures, but also animations and interactive 3D visualizations and simulations. Students are able to interact with virtual 3D tools. At the same time a virtual laboratory trains students to solve problems and learn-by-doing. Some other advantages of virtual laboratories can be summarized as follows:

- free access of large number of students - training access to real equipment or production lines is limited or not possible at all;
- most effective use of educational resources – 24 hours daily students access, compared to real laboratory, where students have access one or two semesters per year, a few hours per day;
- safe usage - without risk of injury compared to work in real conditions, when incidents are possible;
- unlimited access, which in real laboratories is sometimes impossible because of the lack of time and insufficient number of available equipment, technologies and tooling for the simultaneous work of all students in the laboratory;
- using three-dimensional models in virtual learning environment allows students to measure parameters which are very hard to be measured in real terms.

### LAYOUT

This paper presents a 3D virtual training laboratory in Cutting Tools. Cutting is a fundamental operation for forming and designing shapes. Cutting tools play an important role in the present manufacturing industry.

### FACE-TO-FACE TRAINING IN CUTTING TOOLS

Training of cutting tools is important for the understanding of the cutting process. "Cutting Tools" is a bachelor's degree course in the department of "Machine Tools and Manufacturing" in the University of Ruse. The main goal of the discipline is to teach the students about tools design, geometry, technological capabilities and exploitation conditions. The course contains general information about cutting tools: tools for turning, drilling, reaming, boring, milling, threading, pull-broaching, gear-cutting and abrasive machining [1,2,3]. The theoretical material from the lectures is applied during the laboratory exercises, where students individually check, measure, draw the geometry of the tools, and define the technological parameters for exploitation and sharpening.

### VIRTUAL TRAINING IN CUTTING TOOLS

A real laboratory cannot be replaced by a virtual one. Virtual simulation of the measurement cannot give that sense to students that they would receive in the use of measuring instruments in real face-to-face laboratories. However, virtual learning tools can be used very successfully for distance or continuing education. The laboratory

presented will be used for virtual learning in different engineering student courses, where constructive and geometrical cutting tools characteristics are examined. For many courses in which practical exercises are associated with work in laboratories and workshops using various technological equipment, tooling, machine tools, as well as measuring instruments and devices, it is appropriate to create such virtual training laboratories.

The 3D virtual laboratory will allow students to navigate, interact and get a sense of real tools, which are used in face-to-face practical workshops, with the help of three dimensional virtual tool models. The advantages of the 3D laboratory are: the ability to view the whole object in 360-degree; the ability to zoom it and quickly navigate through different viewpoints. The use of 3D graphics provides an attractive opportunity for increasing the student's attention and activity. Applying state of the art 3D CAD/CAM systems in the learning process is becoming very popular because of the ability to represent technological equipment, tooling, machine tools and measuring instruments in digital format and transfer them electronically as 3D objects.

We designed a 3D virtual training laboratory in cutting tools, in which students can virtually learn cutting tools characteristics, measure their parameters and find out how to restore their cutting abilities. The aim of this 3D virtual training laboratory is to offer essential and well-structured information about the cutting tools, show various types of cutting tools by photo and video materials, offer the students the possibility of testing their theoretical knowledge in a test area, help them in virtual experimental work by offering instruction information, and, last but not least, provide opportunity to fill-in student reports.

The 3D virtual training laboratory in Cutting tools provides the students with an environment which simulates a real set of workshops in the "Cutting Tools" course. In order to get experience close to the face-to-face learning, students need to have all kinds of interaction with all types of tools that they can come across during the real work in the "Cutting tools" course workshops. Real laboratory equipment, tooling, machine tools and measuring instruments for the whole course are replaced by corresponding virtual 3D objects. In fig. 1 the real and virtual 3D object of specific equipment for measuring of constructive and geometrical cutting tools parameters are shown.

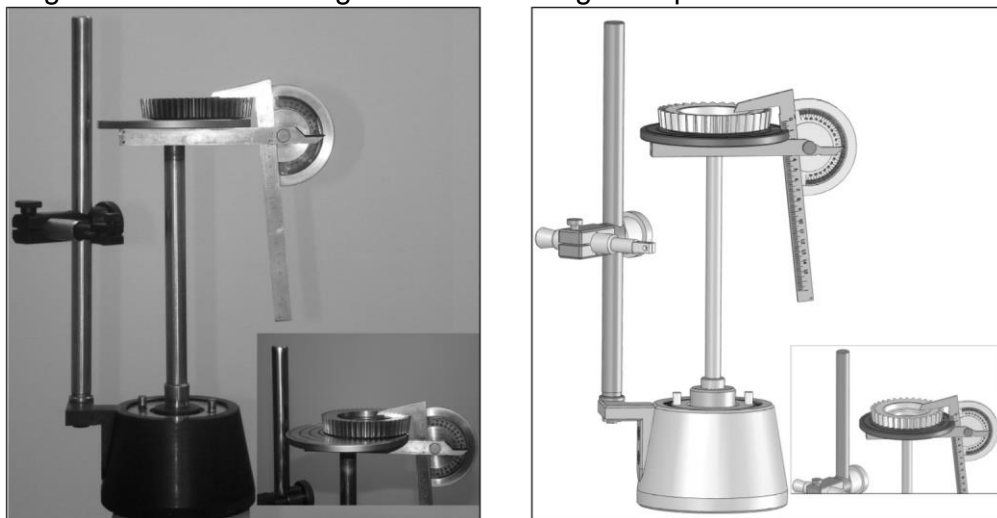


Fig. 1. Real and virtual 3D object of specific equipment for measuring of constructive and geometrical cutting tools parameters

#### CONCEPTUAL MODEL

The virtual laboratory includes interactive tools for twelve workshops:

- Measuring of constructive and geometrical Turning Tools parameters.
- Measuring of constructive and geometrical Drill Tools parameters.

- Measuring of constructive and geometrical parameters of Sink Tools and Reamers.
- Measuring of constructive and geometrical Milling Tools parameters.
- Measuring of constructive and geometrical Thread Cutting Tools parameters.
- Measuring of constructive and geometrical parameters of Broaches.
- Measuring of constructive and geometrical parameters of Gear Cutters.
- Measuring of constructive and geometrical parameters of Hob Milling Cutters.
- Turning Tools sharpening.
- Drill Tools sharpening.
- Sharpening of Sink tools and Reamers.
- Sharpening of Gear cutters.

The virtual laboratory conceptual model is presented in fig. 2. The virtual laboratory (VL) is designed from separate functional parts, which form the whole construction. This approach is closer to the requirements for virtual environments i.e.: to be functionally completed and, at the same time, to allow for innovation and expansion. The proposed VL conceptual model includes three parts: Learning Resources, Help Resources and Learners Resources. Learning resources includes lectures, tests and twelve interactive tools for each workshop. Help resources are designed to answer the user's need of consultations and includes useful information such as: instructions; help topics; FAQ; etc. The students go through the whole training process in the VL with the help of tips. Learners' records consist of: statistics for students' activity (visits, spent time), test results, marks, etc.

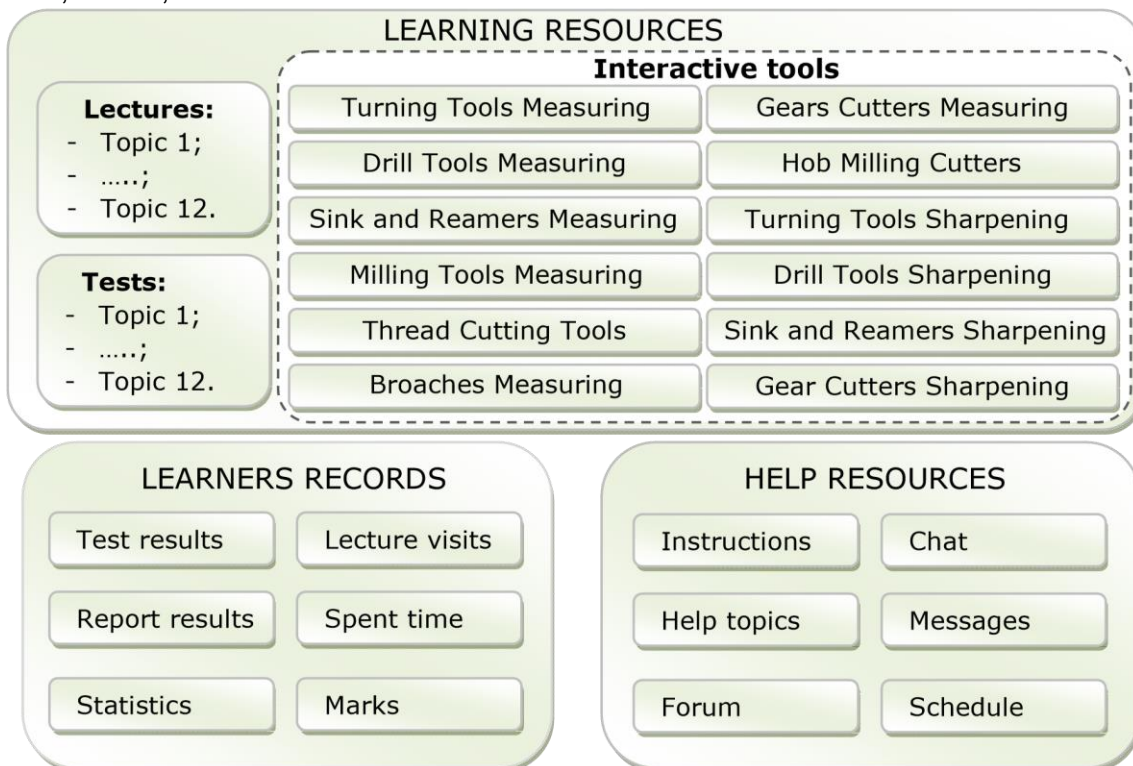


Fig. 2. A virtual laboratory conceptual model

#### VIRTUAL LEARNING METHODOLOGY

The learning methodology is very important for active virtual learning. Figure 3 shows a learning methodology for 3D virtual training laboratory in cutting tools.

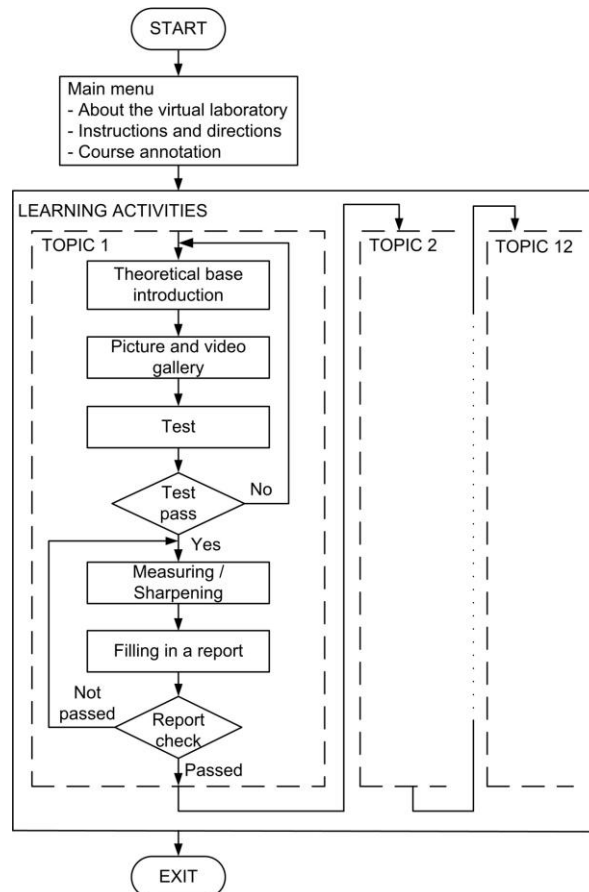


Fig. 3. Virtual learning methodology

As figure 3 shows, learning can be adjustable according to results. Student's results are evaluated according to the formalized criteria. Dynamic reconstruction of the planned learning is possible.

In the beginning, students have to read information about the virtual laboratory with specific instructions and directions how to work and navigate in the laboratory. The second step in the learning methodology is to read short information about the "Cutting Tools" course.

The interactive learning tool will conduct students in their educational process through the following stages in each workshop:

Stage 1: Theoretical base introduction;

Stage 2: Viewing pictures and videos in the gallery, associated with the topic under study;

Stage 3: Testing students' theoretical knowledge;

Stage 4: Depending on the test results, students could proceed with the practical exercise or go back to Stage 1;

Stage 5: Performing measurement and sharpening processes with the virtual cutting tools according to predefined methodology for workshop conduction;

Stage 6: Filling in a report with measuring results;

Stage 7: Depending on the results, students could go on to next topic or go back to Stage 5.

During the training, all information about student's activity and results is stored. The activities and results of different persons can be compared and analyzed. Such approach can show the dynamics of the training progress for each student.

The use of 3D virtual objects in the teaching process makes it possible to conjure visualisations that cannot be achieved using traditional teaching materials. 3D virtual models were developed and used to enhance the student understanding of complex concepts as shown in figure 4. Fig. 4 presents exploded view of the special mill cutter: main body; fasteners and cutting inserts. The figure is part of the theoretical base for measuring of constructive and geometrical Milling tools parameters.

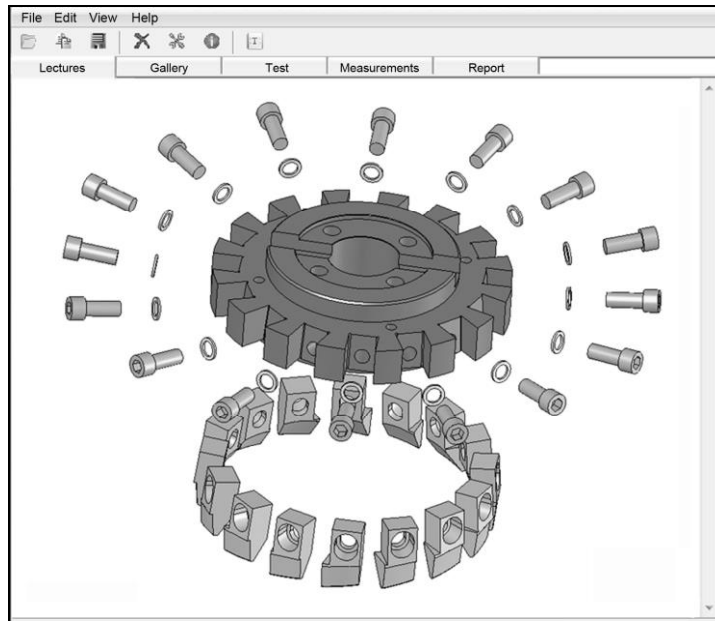


Fig. 4. Exploded view of special mill

Fig. 5 shows the measurement of the diameter of the front guiding part of the broaches using virtual micrometer. Students need to read the measured value and to fill in data into appropriate table position. Measuring of constructive and geometrical parameters of Broaches requires usage of three different virtual instruments: Micrometer, Caliper and Babchinicer [4].

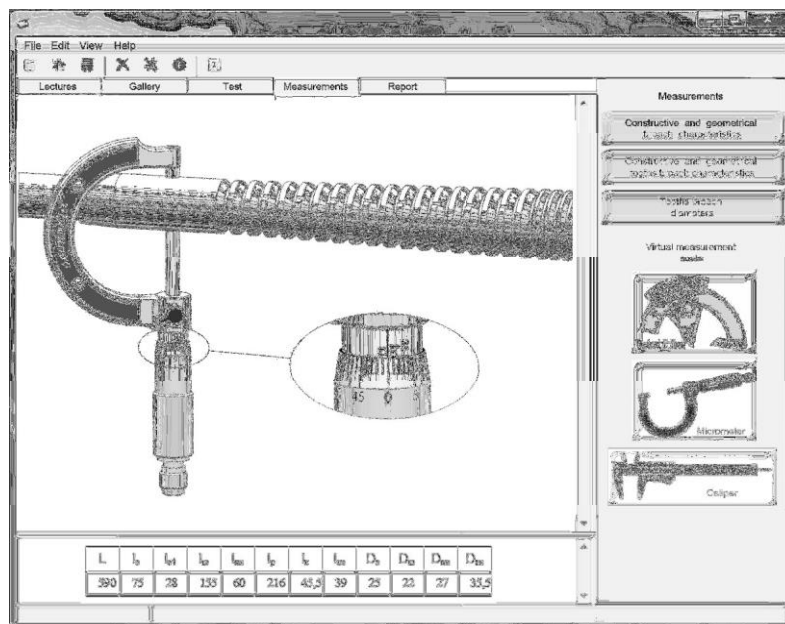


Fig. 5. Virtual measuring of Broaches

Fig. 6 shows a Turning Tool sharpening with diamond disk. In the figure 6 two of the main stand parts are transparent allowing students to see hidden components, which is not possible in real face-to-face learning.

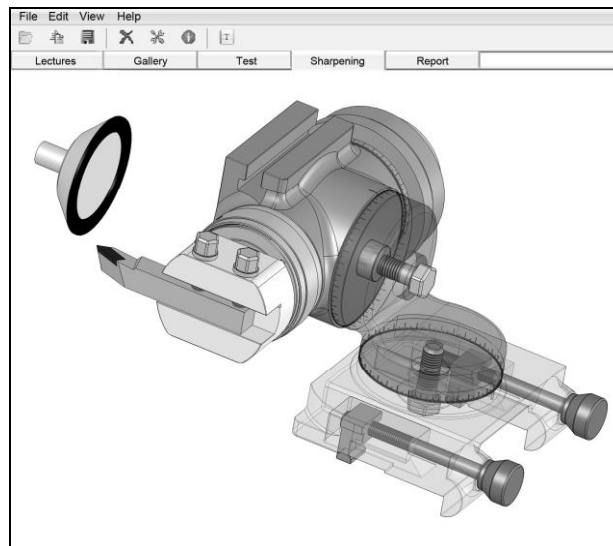


Fig. 6. Turning tool sharpening

### CONCLUSIONS AND FUTURE WORK

Using 3D Virtual Training Laboratory in Cutting Tools students can study different cutting tools interactively and easily get detailed information of them and their properties. At the moment the laboratory is still under construction. The interactive tools are developing using Java, Flash and Delphi programming languages. All 3D virtual models are already created using SolidWorks in Rapid Prototyping Laboratory in University of Ruse.

The 3D Virtual Training Laboratory in Cutting Tools consists of virtual 3D models of real equipment installed in a real Cutting Tools Laboratory. Students have a unique possibility for distance work with that equipment on their computer screens. Only one mouse click is necessary on 3D objects for displaying more detailed parameters and viewpoints. The learning process is built on the usage of realistic 3D objects simulations. Virtual simulations and animations provide the capability of training students in Cutting tools without the need to work with real equipment and tools in the laboratory. The complexity of virtual simulation depends on the task and varies from simple interaction with a single cutting tool to simulation of the operation of complex technology equipment.

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